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# Attracting and trapping insect vectors

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*Animal trypanosomosis constitutes a significant barrier to the development of farming and food security in the regions of Africa where they are prevalent. Their transmission is mostly due to tsetse flies (figure 1) which are their cyclical vectors, but they can also be transmitted by mechanical vectors such as Tabanids (figure 2) and Stomoxys flies.*

*These insects hunt on sight and are also attracted by the odor of their host animals. Traps or toxic targets should therefore become visual and olfactory baits.*

*The basic trapping principle is to attract insects that are looking for a host, using visual and possibly olfactory lures to lead them inside traps, either to keep them alive using a capture system, or to kill them with an insecticide. Trapping has been an effective way of capturing, studying, sampling, protecting and fighting against tsetse flies for many years.*

## Attractiveness and efficiency of traps

Both the attractiveness (measured by the number of attracted insects) and efficiency (measured by the proportion of insects caught to those attracted) depend on many factors, some being insect-specific and others trap specific.

### Insect-specific factors

They maybe physiological or ethological, both influenced by the habitat and other unknown factors. However, the visual and olfactory aspects of traps are always essential.

### Physiological factors

Hunger is a critical factor that cyclically increases the search for a host; thus in tsetse, the daily capture of previously marked and released laboratory flies presents sinusoidal patterns whose peaks correspond to the period in-between meals. The gestation period, which increases appetite on days 1 after fecundation and days 6-7 in tsetse, also results in the increased capture of females.



Figure 1. Tsetse fly- Trypanosome cyclic vector.  
(Photo J. Bouyer)



Figure 2. Tabanid- Trypanosome mechanical vector.  
(Photo M. Desquesnes)

Sex is without doubt a major factor in the capture of tabanidae given that it is the blood-sucking females which are mostly captured, illustrating the fact that the trap acts as a surrogate host. Sex ratios are very variable in *Stomoxys*, depending on the season. In tsetse, trap attractiveness has a similar effect on both sexes, with more females being captured by time unit because of more frequent feeding events.

It is difficult to assess the effect of age on insect capture given that the real population age pyramid is unknown. In tsetse flies however, it is generally accepted that capture using traps will better represent adults than teneral whereas capture made using nets or resting traps better represent teneral flies, in a proportion close to reality.

In addition, recent experiments at CIRDES have shown that *riverine* flies can learn to recognise their host. It is therefore possible that the insect's trophic context and experience can influence the attractiveness and efficacy of a trap. This might explain why teneral flies, which need all stimuli (movements, odour and visual) to be attracted are less captured in traps.

## Vision

Three-dimensional shapes are more attractive than the bi-dimensional forms, and attractiveness increases with the size of the trap in tsetse flies in the *morsitans* group whereas in some species like *G. fuscipes fuscipes*, small targets have a good efficacy (and even a better trap index per sq-m of fabrics than bigger traps). Movement (as in the case of mobile traps) mostly attracts male tsetse and some species such as *G. morsitans*. It is likely that similar behavioural patterns can be observed in other biting insects.

Colour, especially the wavelength of reflected radiation, plays a very significant role.

Phtalogene blue is by far the most attractive colour for *G. p. gambiensis* and *G. tachinoides*, and for numerous other blood-sucking insects. In Africa, particularly for certain species of the *morsitans* and *palpalis* groups, insects are drawn towards black, hence the mixing of blue and black in a number of different traps and targets. Blue is used outside the trap to lure insects from a distance, and black inside the trap so that insects can enter and land on it. Black surfaces are mimetic of the shadow, thus of sloping parts of the animals which are favoured as biting sites.

The contrast between dark and bright surfaces improves the efficiency of the trap, and the same goes for the contrast of the trap in relation to its immediate environment.

## Odour

Blood-sucking insects looking for a host also rely on olfactory perception and react to smells such as: urine, excrement, exhalations (gases emitted through the mouth or anus), and animal body odours. Odour attractants are therefore used to increase trap yields. Some reptiles are particularly attractive to tsetse, like lizards and crocodiles (figure 3).

From the identified attractant products in mammals, carbon dioxide works best, but it is not practical to be used in the field (bulky gas cylinders or very expensive dry ice). The chemicals that can be used which have a small footprint and a reasonable price can be divided into three groups: -*ketones*, such as *acetone*, a natural product found in urine, milk, various body secretions and in the breath, or *butanone* (urine, milk); -*octenol* (1-octen-3 ol), a product of the oxidation of unsaturated fatty acids that is naturally found in the body odor of cattle; - *meta-Cresol* - a phenolic derivative found mostly in the urine of mammals.

## Environmental factors

The location of the trap is important, especially for *palpalis* tsetse flies which are less likely to be attracted by olfactory traps. The area must be clear, in sunlight, located in areas known to be tsetse flies' hunting grounds (bridges, streams, washhouses, selvages, public washing places, wells etc.).

The traps' shape must be studied so that it can be seen from far, and openings must be perfectly located (direction, height, position in relation to surrounding vegetation and along the air corridors most likely to be utilized by the insects). It is difficult to draw up an exhaustive list of recommendations for the correct placement of traps, but it is undeniable that the performance of traps within the same site can vary from one extreme to the other, depending on the tsetse control expert who is setting it.

Installation times and good timing are very important. The best times are those that correspond to maximum insect activity and they vary according to the season. Thus, insect activity is biphasic during the hot dry season and monophasic during the cold dry season in most vectors. However, some species have idiosyncratic behaviours (e.g. *Tabanus laverani*, which is active at the end of the afternoon).

Typical trapping must therefore cater for the totality of the activity period. In addition, insect distribution is seasonal, for example *riverine* tsetse flies are only concentrated along the hydrographic network during the dry season, which makes it easy to capture them.

Climate is equally important; a cloudy and cold day may result in a huge reduction in captures. Continuous rain also results in zero capture.

Positioning is important when it comes to asymmetric traps such as the Nzi trap, since only one of the three facades allows insects to enter into the trap; the traps must therefore be located in open spaces.

Finally, the availability of natural hosts (which "compete" with traps) in the vicinity is an important factor to the trap's performance and attractiveness.



Figure 3. Reptiles that attract tsetse flies: monitor lizard (left) and crocodile (right).  
(Photos M. Desquesnes)

# Importance of trapping

## Vector and trypanosome risk studies

Standardisation of field captures using traps facilitates numerous investigations into the biology and ecology of tsetse flies and mechanical vectors (movement, longevity, distribution, physiology, density, seasonal or annual fluctuations, species' distribution range, competitiveness of sterile males, etc.). A comparison of different trap types and attractants allows us to understand the insects' hunting patterns.

Surveys are conducted using various types of traps and according to protocols adapted to the environment under study. Depending on the surrounding vegetation, spacing traps at 100 metres intervals is recommended when trapping riverine tsetse flies along watercourses. In savannah grasslands, depending on the abundance of vegetation (and therefore the season) a spacing of 200 metres is often the minimum required to avoid interference between traps (figure 4a).

The apparent density per trap per day (ADT) is a widely used indicator for studying trypanosomosis risk. Despite the many variables mentioned above, the use of the same type of trap under standard conditions in different landscapes allows us to define risk indicators as the number of infected insects captured per trap and per day.

The ratio between trap location and ADT is supposedly proportional to the number of attacks experienced by a host – allowing us to calculate risk factors that are related to the abundance of biting insects which can sometimes be very high as is the case with prolific mechanical vectors (figure 4b, 4c). This value can be multiplied by the percentage of infected insects to obtain a risk index called the entomological inoculation rate, corresponding to tsetse challenge.

An area with an ADT of *Glossina palpalis gambiensis* of 10, will then be considered ten times more dangerous than an area with an ADT of 1 of the same species of tsetse flies if the infection rates are equal. The first area will be considered as a priority when fighting against trypanosomes.

As a studying and monitoring technique, trapping allows:

- to establish the diversity and abundance of biting entomofauna;
- to determine seasonal density peaks of biting insects;
- to outline tsetse distribution maps;
- to assess "trypanosomosis risk" (the entomological risk index);
- to compute vector population densities before and during campaigns;
- to detect residual populations or reinvasion 'pockets', etc.

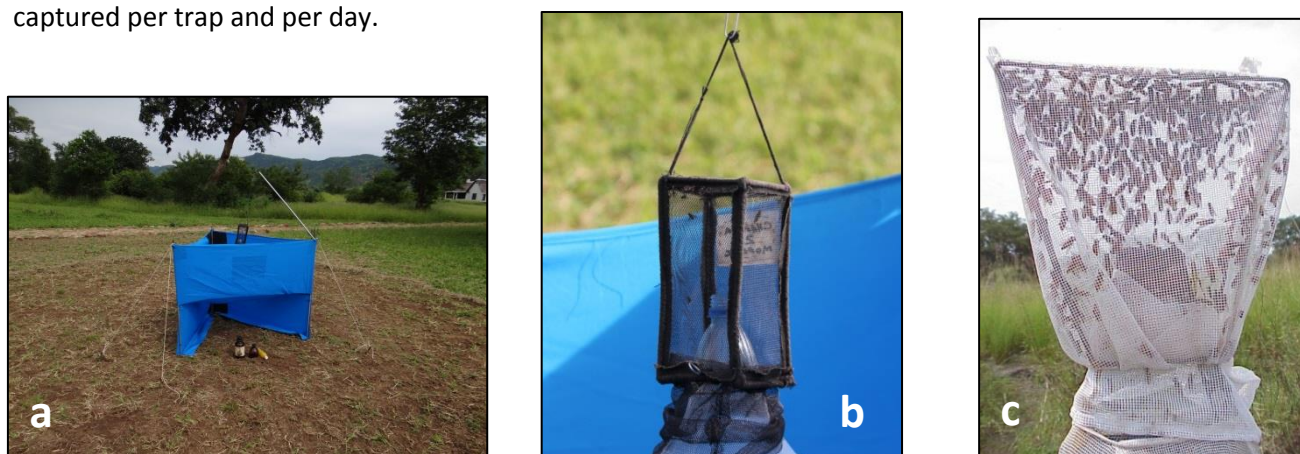


Figure 4. Vector capture: (a) Epsilon traps setup in the savannah ; Small (b) and large (c) cages used to collect insects. (Photos J. Bouyer, L. Guerrini and M Desquesnes)



## Tsetse control campaigns

These campaigns require (1) appropriate means of transport such as 4X4 wheels vehicles that facilitate access to trapping sites, (2) traps or targets in the requisite quantity and quality, and (3) duly trained staff (figure 5) who are conversant with trap layout according to the environment and trap types (figure 4a). The basic equipment will therefore consist of traps, stakes, hammers, cones, cages, containers and machetes.

Simple traps (not containing insecticide) or "killer" traps (containing insecticides), are intended to:

- destroy adult males as well as reproductive females, the latter should be killed before the laying of larvae (10 days old);

- eliminate nulliparous females before these 10 days and during the following 60 days (maximum duration of pupation).

In *G. pallidipes*, a 4% daily extraction/harvesting of the female population normally leads to the elimination of their population due to tsetse flies' extremely low reproduction rate. However, the sole use of these methods does not lead to total eradication, even with an extraction rate of 100% because their efficiency, related to tsetse dispersal, is density dependent. It is therefore necessary to combine them, at the end of campaign, with other methods, such as the release of sterile males, or the replacement of the insecticide by a chemosterilant (bizazir) or an equivalent juvenile hormone that prevents pupal development.

One of the explanations for the non-eradication that happens when simple trapping is used is that some insects are not attracted to the traps, some migrate from localities outside the catchment area of these traps, or that the reduction of dispersal which can be density-dependent decreases the probability of contact between flies and traps. Insects contaminated by chemosterilisants will in turn contaminate these "free" insects, thus expanding the traps' reach.

Traps can be used to create protection barriers against re-invasion after an eradication campaign but it is necessary to evaluate the efficiency of these barriers.

An effective barrier will require the setting up of traps every 100 to 200 m along a watercourse, over a 5-10 km stretch in order to effectively prevent reinvasion of riverine tsetse flies.

A 100% efficiency of a reinvasion barrier is more challenging to attain when dealing with savannah tsetse flies, and it will all depend on both trap density, distance across of the trap area and vegetation density. In Zimbabwe, four parallel treated targets spaced at 150-300m intervals have been used, with a target being set-up every 130 m (i.e. 30 targets per km<sup>2</sup>) (figure 6). Barrier efficiency can be reinforced by other control methods, such as the insecticide treatment of cattle.



Figure 5. A team and its equipment during a vector monitoring campaign.  
(Photo M. Desquesnes)

Traps can be used to control human trypanosomosis (especially against flies from the *palpalis* group). They can also be used in alternation with targets. They have the advantage of being usable without the addition of insecticides and allow people to appreciate their efficiency when they see the dead insects inside, which is very encouraging for them. However, the percentage of insects entering the traps is low (~20%) and traps impregnated with insecticides (and without a cage) should thus be used (figure 7). For economic reasons, targets treated with insecticide are preferable when the area to be covered is vast. The present tendency is to reduce the size of targets but it sometimes imposes to increase their density which is not necessarily cost-effective.

Trap trials are underway in La Reunion Island against *Stomoxys* (*Stomoxys niger* and *Stomoxys cal-citrans*), whose actual densities per farm can reach 100,000 and 200,000 individuals. Preliminary results show that a reduction of their population is observed only when trapping is coupled with other control techniques (e.g. environmental- through the destruction of their breeding area, chemical- such as the epicutaneous livestock treatments, and biological – the release of parasitoids). This is because they have a reproduction rate that is much higher than that of tsetse flies.

Tabanid trapping is essentially carried out for entomological or epidemiological studies; its effectiveness in the trypanosome fight has not yet been validated, however capture scores observed in some contexts suggest that trapping can contribute to the reduction of tabanid population densities (figure 4c).

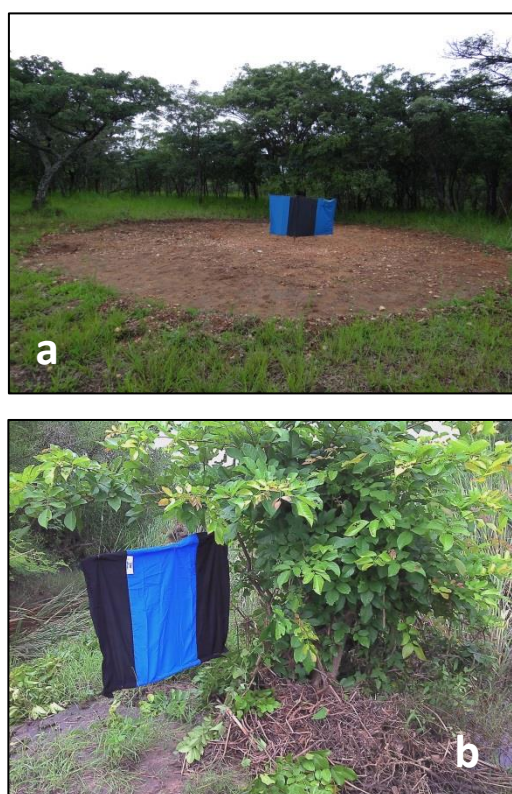


Figure 6. Blue-Black-Blue target set to control tsetse in Zimbabwe (a) and Black-Blue-Black target set to control tsetse in Senegal (b).  
(Photos J. Bouyer)



Figure 7. Vavoua trap impregnated with insecticides, used within the tsetse eradication campaign in Senegal.  
(Photo Abdou Gaye Mbaye)

Table 1 shows the impact of various traps and target densities on different tsetse species whereas table 2 presents the persistency of the insecticide applied to targets depending on the concentration and molecule used. However, most of the programs presently use impregnated targets, for which the persistency is provided by the manufacturer.

Targeted species	Kind of visual bait	Target density (total area)	Treatment duration (months)	% reduction	Source
<i>Glossina morsitans centralis</i> Machado	Targets of black cloth with or without flanking netting panels (ca. 1 m tall × 1.7 m) baited with acetone (130 mg/h) and 1-octen-3-ol (0.5 mg/h)	4/km <sup>2</sup>	-	100%	(Willemse 1991)
<i>G. morsitans morsitans</i> Westwood <i>G. pallidipes</i> Austen	Targets consisting of black cloth and netting	3–5/km <sup>2</sup> (600km <sup>2</sup> )	10	99.99%	(Vale et al. 1988)
<i>G. palpalis gambiensis</i> Vanderplank and <i>G. tachinoides</i> Westwood	1*1m blue screens?	30/km river (3000km <sup>2</sup> )	4	99%	(Cuisance et al. 1984)
<i>G. palpalis gambiensis</i> Vanderplank	black/blue/black targets factory impregnated with deltamethrin (as supplied by Vestergaard-Frandsen)	30/km <sup>2</sup> (10km <sup>2</sup> )	6	62%	(Kagbadouno et al. 2011)
<i>G. palpalis gambiensis</i> Vanderplank	black/blue/black targets factory impregnated with deltamethrin (as supplied by Vestergaard-Frandsen)	60/km <sup>2</sup> (10km <sup>2</sup> )	8	98%	(Kagbadouno et al. 2011)
<i>G. pallidipes</i> Austen <i>G. longipennis</i> Corti	NG2B traps baited with acetone (ca. 150 mg/h) and cow urine (ca. 1000 mg/h)	1/km <sup>2</sup> (100km <sup>2</sup> )	10	98-99% 90%	(Dransfield et al. 1990)
<i>G. palpalis gambiensis</i> Vanderplank	Vavoua traps impregnated with deltamethrin (as supplied by Vestergaard-Frandsen)	30/km <sup>2</sup> of suitable habitat	6	99%	Confidential 2011 Niayes eradication project
<i>G. palpalis gambiensis</i> Vanderplank and <i>G. tachinoides</i> Westwood	black/blue/black targets 1*1m impregnated with deltamethrin (locally, in CIRDES)	17±4 screens / km river course (big rivers) and 9±2 screens / km river course (big rivers)	2	95%	Confidential 2011 PATTEC BF

**Table 1.** Trap densities applied during various tsetse control effort and observed impact on tsetse densities.

	Active matter C.S.	Desired persistency	Quantity of insecticide necessary
<b>Pyrethroids</b>	Deltamethrin	2 months	100 à 200 mg/m <sup>2</sup>
	Deltamethrin	9 months	800 mg/m <sup>2</sup>
	Alphacypermethrin	9 months	800 mg/m <sup>2</sup>
	Betacyfluthrin	12 months	1304 mg/m <sup>2</sup>
	Lambdacyhalothrin	1 month	100 mg/m <sup>2</sup>
<b>Growth inhibitor</b>	Triflumuron	6 months	6000 mg/m <sup>2</sup>

**Table 2.** Persistency of the insecticides against tsetse depending on the concentration used for impregnation.



## Main traps used in Africa

All traps meant for capturing tsetse have a similar appearance, consisting mostly of a variable shape (prism, cylinder or cube), an blue attractive surface with windows allowing the insect to enter, a mosquito netting part guiding the insects to the top, an anti-escape device (a pyramid or a slot between two planes in a V shape) and a capture device at the top of the trap.

Trap types vary according to shape, colour, whether or not olfactory baits, insecticides or chemosterilisant products are used. Recent models have the advantage of being simple, lightweight, foldable (allowing easy transportation), economic and quick to set-up. They mainly consist of blue and black cloth, mosquito netting, wood or metal frame, and stakes/poles.

### Challier-Laveissière Biconical trap (1973, Burkina Faso and Côte d'Ivoire)

It consists of two cones connected at the base (with a diameter of 80 cm), the upper cone is made of mosquito netting and the other cone is made of blue cloth, with four elliptical openings - (figure 8a). The inner part of the lower cone is divided into four compartments by four segments of black cloth. The trap is supported by a vertical metal rod stuck in the ground and a supporting cone that functions as an anti-escape device, with a harvesting cage. This is a trap very effective in catching *riverine* tsetse (of the *palpalis* group). It is widely used throughout Africa and is seen as trap of reference. The standard model with a diameter of 80 cm and a height of 133 cm is attached to a stake and its base should be at a maximum of 20 cm from the ground. Other variations include suspending the trap above streams/ivers or by placing it on a floating structure.

### Vavoua Trap (1986, Côte d'Ivoire)

This is a monoconic trap consisting of a cone of mosquito netting attached to three screens joined together at angles of 120°; the central part of each screen is black and the outer part blue tie (figure 8b). The trap's collection system is similar to that of the biconical trap. It can be stuck to the ground by a stake (made of wood or concrete iron) or attached by a string to a low branch or to any other appropriate structure. The Vavoua trap is effective against both *riverine* tsetse flies (*G. palpalis* and *G. tachinoides*) and savannah tsetse (*G. m. submorsitans* and *G. longipalpis*). It is also the most effective trap against *Stomoxys*. It measures 80 cm in diameter and has a height of 118 cm.

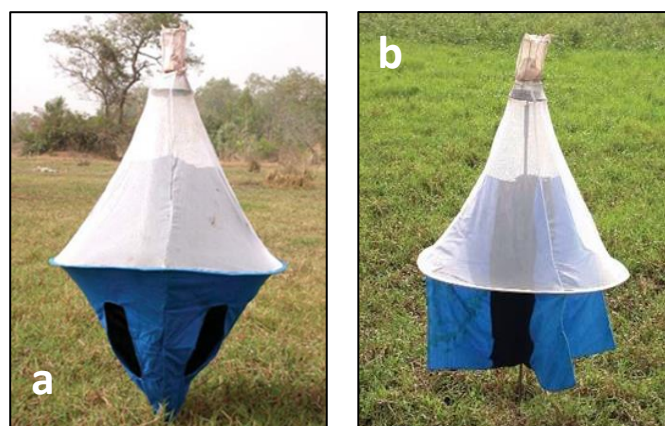


Figure 8. (a) Biconical Trap; (b) Vavoua Trap.  
(Photos M. Desquesnes)

### Gouteux-Lancien Pyramidal trap (1984, Congo)

It consists of a pyramid with a square base made of mosquito netting attached to two blue and black screens that vertically intersect at right angles and held upright by two wooden poles (figure 9). It is particularly effective for the capture of *riverine* tsetse (*G. palpalis*, *G. tachinoides* and *G. fuscipes*). The trap is 65 cm wide and 115 cm high. When used attached by a string to a low branch, for example, the bottom of the trap should not be more than 50 cm from the ground.

### Gouteux Screen-Trap (1986, Congo)

The version of this trap, modified in 1993 is being used at CIRDES for catching tabanids. It is composed of two rectangular screens, one blue and the other one black, intersecting at right angles and held together by four 63 cm rods (figure 10). It is covered by a mosquito netting cone with netting materials hanging on each side of the structure. A mounted trap is 90 cm wide and 135 cm high. It is suitable for trapping savannah tsetse flies, tabanids and *Stomoxys*. The main difference between this trap and the pyramidal trap lies in the flaps.

### Nzi trap

The Nzi trap, developed at ICIPE by Steve Mihok, from NG2G model traps by Brightwell and al. (figure 11). Its front has got a blue horizontal rectangular panel with two blue rectangular wings fixed on stakes extending out at an angle of about 120° from the front. These 'wings' form an arch which is the trap's entrance. A trapezoidal piece of netting extends horizontally half-way into the body from the bottom of the blue shelf. The blue panels are connected to black panels forming a penetration cone. The back of the trap, held upright by a pole is made of mosquito netting for attracting insects towards the bottom and the top of the trap; there is a pyramidal shape made up of mosquito netting on top of the structure (light passing through attracts insects towards the bottom and then upwards), the top is closed by a cone (the anti-escape device) which guides insects into the last capture cage. The trap is secured to the ground by three external metal stakes and a central pole, or a flexible wooden stick, making it a relatively bulky and time consuming trap to setup (four metal stakes driven into the ground and more than eight adjustment points). It is suitable for the trapping of savannah tsetse, tabanids and *Stomoxys*. This is the most efficient trap for tabanids and the most "universal" trap for biting insects.



Figure 9. Pyramidal Trap.  
(Photo M. Desquesnes)



Figure 10. Screen- Trap.  
(Photo M. Desquesnes)



Figure 11. Nzi Trap.  
(Photo M. Desquesnes)

## Epsilon trap

The Epsilon trap was developed in Zimbabwe for trapping savannah species such as *Glossina pallidipes* and *Glossina morsitans* (figure 12). The trap is an equilateral triangle with a side length of 120cm and the lower half of the front is folded back into the trap to give a horizontal shelf. The outside of the trap is blue and a vertical black cloth (0.5 x 1m) is sewn into the rear of the trap to elicit a landing response inside the trap as well as creating a dark environment. The top of the trap is covered with netting material to create a cone which is recessed with its apex level with the top and forward of centre. A plastic cage is used to collect trapped tsetse. The trap is supported internally by aluminium poles held upright by guy ropes. The installation steps of an Epsilon trap is presented in figure 14.



Figure 12. Epsilon Trap.  
(Photo J. Bouyer)

## H trap

The « H » trap was developed at Hellsgate Tsetse Research Station in South Africa for the simultaneous collection of live *Glossina brevipalpis* and *Glossina austeni*. It was designed following a negative evaluation of the responses of the two species towards traps that are used elsewhere in Africa for the collection of other tsetse species. The odour-baited blue and black H trap represents a different approach for trapping tsetse flies as it is fitted with lateral cones of white netting which induce the flies to take a more horizontal flight path once they have entered the trap, instead of the vertical flight paths they assume in existing tsetse fly traps. A number of modifications of the prototype H trap were devised (H1-H5), before the final design was established. The final modification caught a record number of 180 *G. brevipalpis* and 57 *G. austeni* on a single day (figure 13).



Figure 13. Photograph of the final H trap.  
(Photo Chantel J. de Beer, OVI)





Figure 14. Installation steps of an Epsilon Trap  
(Photos L. Guerrini)



# Choice and use of traps

## Choosing a suitable trap

It can be seen from the reviewed traps that each trap has its advantages and disadvantages (light/heavy, cheap/expensive, etc.), unique characteristics (suitable for trapping along river banks, in the savannah, in forests, etc.) and above all performances based on the spectrum of target species and the environment in which they are installed.

Trap choice in a research or control protocol will therefore depend on target species and the environments in which traps will be used (table 3), or the desire to draw comparisons between a current and past situation, in which case it is essential to use the same trap.

Thus, biconical and Vavoua traps are well adapted for the capture of *riverine* species along water courses. It is advisable to use Vavoua traps for capturing *Stomoxys*, *Chrysops*, *G. palpalis* and *G. tachinoides*. Although the biconical trap has become the reference trap for the latter two species, it is unsuitable for the capture of *Glossina morsitans* in the savannah. It is preferable to use Nzi trap, its size and insect access mode is more adapted to species with a fast and powerful flight.

When the objective is to evaluate the entomofauna biodiversity of a given site, a wide array and variety of traps must be used. Additional traps not described in this document can be used, such as the Canopy trap and the Malaise trap; the last been efficient to catch *Hematopota* and *Musca crassirostris*(hematophagous sucking fly).

Trap model	Target species								Mechanical vectors	
	Tsetse									
	Riverine species			Savannah species				Forest species	Tabanides	Stomoxes
	<i>G. palpalis</i>	<i>G. tachinoides</i>	<i>G. fuscipes</i>	<i>G. longipalpis</i>	<i>G. morsitans</i>	<i>G. pallidipes</i>	<i>G. austeni</i>	<i>G. brevipalpis</i>		
Biconical	+++	+++	+++	++	++	+	NA	+	+	++
Vavoua	+++	+++	+++	+++	++	+	NA	+	++	+++
Pyramidal	++	++	NA	+	+	NA	NA	NA	++	+
Nzi	+++	++		++	++	NA	NA	NA	++++	+++
X sticky	NA	NA	NA	NA	NA	NA	+++	+++	NA	NA
H3	NA	NA	NA	NA	NA	NA	+++	+++	NA	NA
F3	NA	NA	NA	NA	++	+++	NA	NA	NA	NA
Epsilon	NA	NA	NA	NA	++	+++	NA	NA	NA	NA

**Table 3.** Table giving the suitability of different trap models depending on the tsetse species targeted, based on trap efficiency (NA = Not available, + low trapping rate for this species, ++ medium trapping rate, +++ good trapping rate).

Sources: (Kappmeier 2000, Vale and Torr 2004, Bouyer et al. 2005).

## Trap construction

In order to produce standardized sampling, traps must be uniformly built and well maintained (no faded fabrics). The ideal situation is to have a standard reference model.

The colour and the type of fabric are very important. Thus, different blue fabrics can have radically different attractive capabilities, and synthetic fabrics are often less attractive than cotton or blends containing cotton at the same wavelength (figure 15). In addition, some fabrics fade more easily under the effect of rain and the sun. The choice of the fabric is therefore crucial and it is necessary to refer to proven products. Multiple comparisons indicate that blue "Santiago" fabric is closer to phtalogen blue and is therefore recommended to use when making traps. The requirements for the black fabric (insect landing area) are less stringent than those for the blue fabric (the trap's attraction).



Figure 15. Two blue fabrics identical in appearance: on the left the more efficient "Santiago fabric" (made of cotton), and on the right an inefficient synthetic fabric.

(Photo M. Desquesnes)

It is essential to maintain (check the mosquito netting's tightness) and refurbish the traps when their colour fades with ageing, otherwise their efficiency will be greatly reduced (figure 16). It is however crucial to check the quality of the material which is unfortunately not standard, which can impact negatively the quality of monitoring surveys or the efficiency of control campaigns. There is presently an urgent need to set up an independent quality control centre to validate the quality of the material sold by these companies.

Two companies are specialised in the manufacturing of traps and/or their fabrics:

Vestergaard Frandsen Group (fabrics and traps) Akseltorv 4 B - Dk - 6000 Kolding, Denmark

Tel.: 4575503050 / fax: 4575503044

E-mail: sales@vestergaard-frandsen.com

TEXICODI ("Santiago" fabric)

01 BP 578 Bouake 01 Côte d'Ivoire

Tel: 225 63 32 13/14/24/74/36

Fax: 225 63 49 62

However, traps may be made with local fabrics providing they have been validated under Latin square comparison with a reference fabric such as Santiagno or TDV S250 Azur 023.



Figure 16. Vavoua traps: new, with bright color (left) and old, tired off and fade color (right)

(Photo M. Desquesnes)

## How to improve trap efficiency

Trap efficiency can be improved by the use of olfactory attractants. Odour baits have a range of activity below 100 metres and their location relative to the trap plays a significant role. However, improper use can even lead to reduced catches; for example, catches are reduced when the attractant mixture is placed 4 m instead of 30 cm from the lure. Olfactory attractants can sometimes be placed inside the trap, but in such cases, the permanent effect that the attractant has on the trap makes it unusable for other purposes. Some baits may even become repellents if their concentration is too high; this is especially true for cow urine, octenol when used for *Glossina pallidipes* and butanone. It is therefore important to adhere to recommended doses (table 4) and/or delivering methods (bottle with a wick, in addition to the use of porous material, etc.).

Different diffusion methods may be used, depending on the attractant, here are some examples:

- For ketones or urine: bottles or glass vials are placed at the foot of the trap, the evaporation rate depends on the bottle's aperture size and the wind. Thus, for acetone (recommended flow 150 to 2500 mg/h), apertures of 2 mm and 6 mm in diameter lead to flows of 150 and 500 mg/h respectively. Cattle urine yields a flow rate of 1000 mg/h with a 45 mm diameter aperture;

- the same containers, but with a raised upside-down rubber stopper for octenol and phenols;
- porous polyethylene bags of 12 to 15 µm thickness that are attached to the traps for metacresol/octenol mixtures. A 5 x 4 cm bag has got a flow of 0.5 mg/h.

Substances that are in current use are more attractive to savannah rather than riverine species, but active research in this domain has been conducted recently. For example, cattle urine with a 1000 mg/h diffusion flow allows the following increase in catches; 10-20 times for *G. pallidipes*, 5 - 10 times for *G. longipennis* and only 1,7-3 times for *G. tachinoides*.

Species	Attractant	Diffusion output	Increase of captures
<i>G.m.submorsitans</i>	Acetone	400-1200 mg/h	1.8-2.3
<i>G.morsitans</i>	Acetone Octenol	150 mg/h 0,5 mg/h	1.5-7
<i>G.longipalpis</i>	Acetone 3-methylphenol 4-methylphenol	500 mg/h 1 mg/h 1 mg/h	3-4
<i>G.medicorum</i>	3-methylphenol	1 mg/h	2.8
<i>G.tachinoides</i>	3-methylphenol Octenol	1 mg/h 0.5 mg/h	1.5-2.5
<i>G.tachinoides</i>	Octenol	0.6 mg/h	1.3
<i>G.p.gambiensis</i>	POCA	See legend	1.8-2.2
<i>G.tachinoides</i>	POCA	See legend	2.1-8.5 males 1.3-7.5 females

**Table 4.** Potential increase of captures with various attractants and tsetse species: (POCA consists of P = 3-n-propylphenol (~0.02 mg/h); O = 1-octen-3-ol (~0.2 mg/h); C = 4-methylphenol (~0.4 mg/h); A = acetone (~500 mg/h); CO<sub>2</sub> is not presented because very expensive and difficult to use in the field).

## How to use a trap

### Installation and location

When measuring apparent densities, traps must be set up before the beginning of insect activity.

The performance of stationary trap depends on its location: it is essential to choose trapping sites that are in open areas and exposed to the sun. If necessary, cut the vegetation that hinders trap visibility on a radius of several metres around it. When dealing with tall savannah grass around a trap, clear a radius of 4 m to 5 m (figure 17), machetes and hammers have become the trap setter's weapons of choice!

It is important to protect captured insects from ants attacks if one wants to count, preserve and analyse them. To do this, coat the picket and all the trap's points of attachment with glue or grease. In general, ensure that the trap does not come into contact with any vegetation.

It is absolutely essential that traps used in the study of vectors do not come into contact or be contaminated by insecticides, repellents or any products likely to impact on their performance. The storage rooms of such products must be different and as far away as possible from "neutral" traps.

Always check the integrity of capture cages and the positioning of cones (keep a needle and sewing thread with you for ny eventual repairs in the field).



Figure 17. Cutting the grass around a trap  
(Photo M. Desquesnes)

During systematic sampling surveys requiring the deployment of many traps, ensure to have very strong and lightweight mounting poles (for example, a 160 cm long number 12 rebar pole or number 16 galvanized tube weighs about 1.2 kgs, and less than 0.5 kg for a cylindrical tube).

Biconical or Vavoua traps are generally placed at 100 m intervals for apparent density assessment. Along watercourses, choose trapping sites that have a good sunlight exposition where tsetse are known to 'hunt', along the water's edge (figure 18). Placing the trap in a dark place or far from the water's edge can lead to a 99% reduction in catches.

When using a NZI trap, make sure that the trap opening is facing an open area, ensure correct tension, and the trap should be placed as close as possible to the ground. In the forest, direct the trap opening to a clearing. On forest edges, place the trap more than 15 m from the forest. The distance between traps must be greater than 200 meters in an open environment.



Figure 18. Proper placement of a biconical trap along the water's edge in Burkina Faso.  
(Photo L. Guerrini)



When using a Vavoua trap to control *Stomoxys*, yields can vary from 1 to 100 depending on trap position in the field within a farm. For the tsetse control campaigns, it is essential that traps are set up between the tsetse insect resting places (bushes, walls, barriers where high fly densities can be observed) and host areas (housing area, cattle pens, etc...) to get maximum efficiency. Recently, it was proposed to surround pig or cattle pens with insecticide impregnated fences which is very efficient to protect the animals (figure 19).



Figure 19. Installation of ZeroFly® (modern farm on the top and traditional pen at the bottom)  
(Photos J. Bouyer)

## Harvesting/Collection

When assessing apparent density, ensure that the trap is only removed after the end of the target insects' activity period.

It is necessary to ensure that all insects (sometimes numerous) remaining inside the trap are pushed to enter the cage, at the time of harvesting. It is indispensable to collect traps regularly for nictemeral activity studies (every two hours). Cages must be placed in favourable thermal and hygrometric conditions when the insects are meant for:

- Species identification
- dissection (in order to measure the physiological age of female tsetse, or to assess organs trypanosome infection of in both sexes, or to identify the host in a blood meal)
- measuring the extent of wing wear
- conducting morphological studies.

You can use a special device to keep the insects cool and humid by wrapping a crate made up of metal frames with wet quilted jute fabric (figure 5 and figure 20). The insects will be kept alive in these conditions for several hours and sometimes for days. A long test tube is required to retrieve live insects from cages without harming them.

Insects will barely survive prolonged exposure to the sun and they quickly dry after death or they damage their wings on the sides of the cage if traps are not checked and emptied regularly. In such cases, one can only summarily identify and count them. Another possibility is to keep the cages in ice boxes containing cool-packs which maintain a temperature of  $\sim 10^{\circ}\text{C}$ .



Figure 20. Regular moistening of container containing cages with alive insects for dissection.

(Photo M. Desquesnes)

## **How to organize trapping campaigns**

### **Studying the situation on the ground**

It is essential to have a good knowledge of the entomological situation before any campaign can be held (existing species, infested areas, densities, interaction between insect populations). This stage will allow one to choose the most suitable trap and eventually the best attractant. It is then necessary to test and experiment with the trap on a small scale before extending the campaign to the entire target area.

The prevalence of trypanosomosis needs to be known in order to assess the operation's potential benefits (expected improvements in livestock numbers, productivity, cultivated land, etc.), after the deduction of its net cost (box 2). A good knowledge of resource utilisation and local geography is essential (livestock watering points, transhumance magnitude, hydrographic network, etc.).

### **Identification of an implementing partner**

Depending on the situation, campaigns can be led by state structures, ranchers, or collaboratively by both stakeholders.

In Zimbabwe, in 1988, more than 7 000 sq km were covered by state agencies which had total operational control.

In other countries, the objective is to support the beneficiaries' initiatives (farmers practising animal husbandry, and subsistence farmers). This is the situation in foci of sleeping sickness in Cote d'Ivoire, Congo, Uganda and certain agro-pastoral areas of Burkina Faso where animal trypanosomosis is the main pathological problem to livestock.

Farmers and villagers must be informed and even educated to actively participate in the fight against tsetse, instead of just cooperating. Information can be disseminated via all the available media (posters, flyers, newspapers, radio, television, etc.). Training session can be held through farmer cooperatives, health campaigners, or even by schools, thus training and making aware the farmers' children.

### **How to ensure sustainability of results**

In general, the population mobilization ends with the campaign's success. Awareness campaigns must therefore go beyond the campaign implementation phase. Vector control specialists are responsible for planning, organization and more importantly ensuring the sustainability of achieved results. The supply of campaign material and the organization of all logistics represent money and time taken away from people's normal day to day activities. This is something difficult to demand from people who are not experiencing a state of crisis. In those countries where the government's technical services are gradually being replaced by private entities, we are witnessing increased difficulties in the coordination of anti-tsetse operations, thus leading to mixed and short-term results (See Technical Manual No.14). Traps are often perceived as public property that farmers tend to neglect. A possible solution will be to find a compromise by using other control methods such as insecticide cattle treatment, which is much more appreciated because in such cases, one will be protecting livestock, which constitute personal property, against ticks in the same time.

The use of trapping and/or toxic targets for the study and for campaigns against insect vectors needs to follow a rigorous methodology, whose main components were outlined in this document.

When used correctly, trapping is an extremely valuable and an effective technique for studying vector ecology. In the fight against animal trypanosomosis, trapping can be coupled with epicutaneous treatment, particularly effective during the rainy season when flies actively seek out animals, which then become “keeling live baits”. Research to improve trap performance is still on-going, particularly in the field of olfactory attractants and target size and design.

## The cost of trapping

Trap price varies depending on the local cost of materials (fabric, mosquito netting and frames) and how complex the fabrication process is (these estimations exclude installation poles, cones and cages):

- monoconic, screen and pyramidal traps cost between 10 and 12 euros;
- the biconical traps cost 12 euros;
- Nzi traps cost between 14 and 16 euros.

For all traps, impregnation costs between 0.1 and 0.3 euros, which translates to 1-2 euros per year, at a rate of five impregnations per year. The olfactory attractant price depends on associated products and local conditions, ranging from 1.5 euros (in Burkina Faso), 3 euros (in Zimbabwe) and 5 euros (in Kenya) per trap per year. To these costs must be added numerous expenditures associated with setting tsetse control (clearing the ground, opening/creating pathways) and trap maintenance- just to name a few. In equivalent field scenarios, trapping costs as much as insecticide use during its first year and then less thereafter due to the reutilisation of some of the equipment. This method makes use of local resources and requires minimal foreign currency expenditure. It also has the huge advantage that it has near zero pollution on the environment.

## Use of Insecticide impregnated targets to control tsetse (toxic targets), in brief

	Advantages	Disadvantages
ITT overall	<ul style="list-style-type: none"> <li>- Simple, fast and efficient</li> <li>- Cheap</li> <li>- Low environmental impact</li> </ul>	<ul style="list-style-type: none"> <li>- Public good</li> <li>- Community management necessary</li> <li>- Vulnerable (fire, flooding, robbery...)</li> <li>- Cost of setting</li> </ul>
Attractants	<ul style="list-style-type: none"> <li>- Improved efficiency</li> </ul>	<ul style="list-style-type: none"> <li>- Availability</li> <li>- Technical constraints</li> </ul>
Large screens	<ul style="list-style-type: none"> <li>- Cheaper</li> <li>- Faster</li> </ul>	<ul style="list-style-type: none"> <li>- Induce behavioural resistance more readily</li> </ul>
Small targets	<ul style="list-style-type: none"> <li>- Cheaper</li> </ul>	<ul style="list-style-type: none"> <li>- Increased density</li> <li>- Low visibility in dense vegetation</li> </ul>



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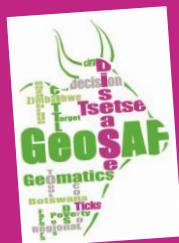
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*This manual is for policy makers, researchers and vector control specialists/ field workers.*



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